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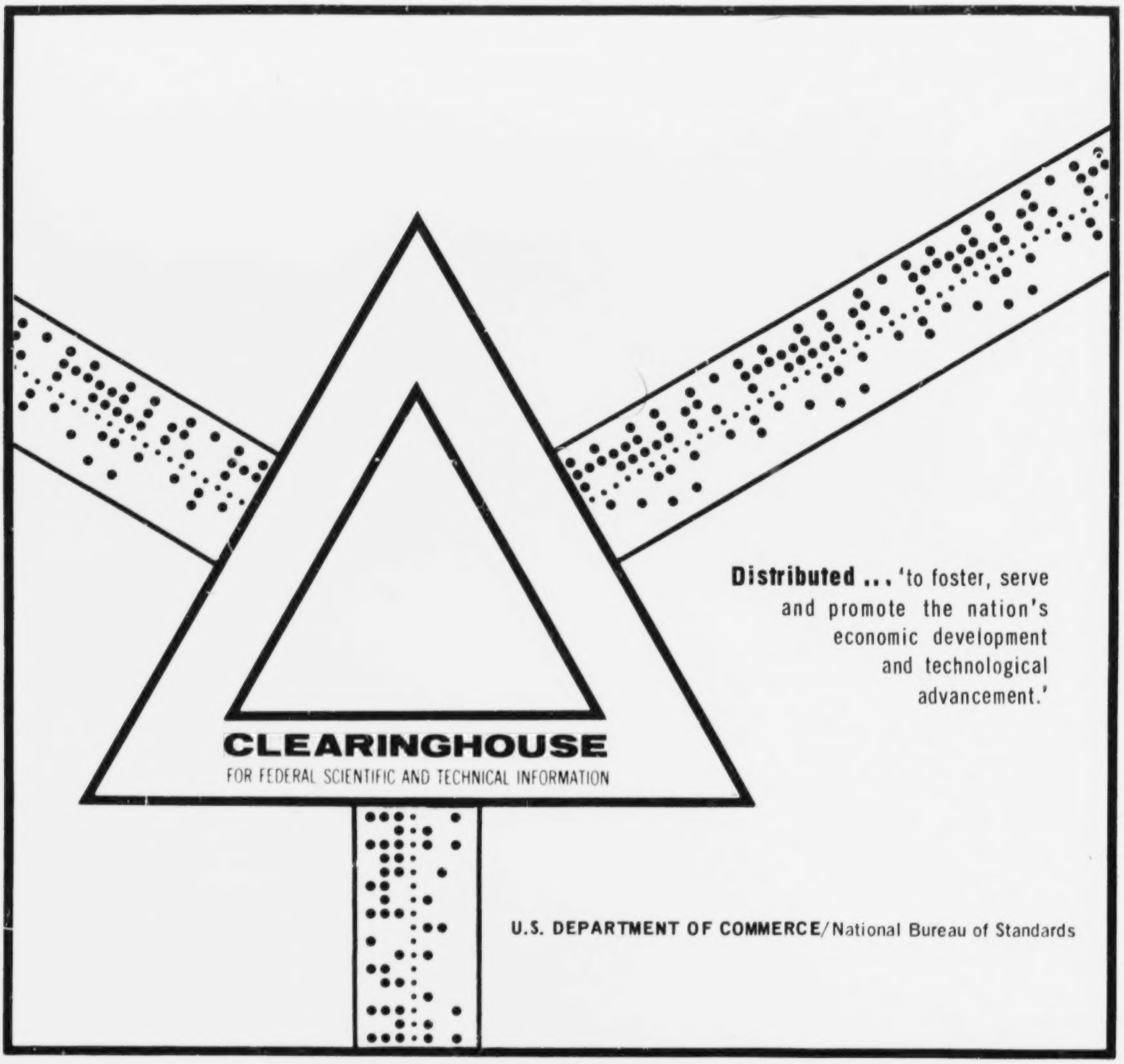
IODINE 131 IN CHILDREN'S THYROIDS FROM ENVIRONMENTAL EXPOSURE

Henry N. Wellman, et al

National Center for Radiological Health
Rockville, Maryland

May 1967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IODINE 131 IN CHILDREN'S THYROIDS FROM ENVIRONMENTAL EXPOSURE

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Public Health Service

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Henry N. Wellman
Gerald J. Karches
Warren G. Hansen
Gerald R. Laurer
Merril Eisenbud
Jack H. Fooks

A report of a cooperative study carried out by the Public Health Service, the St. Louis County Health Department, and New York University.

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Public Health Service
Bureau of Disease Prevention and Environmental Control
National Center for Radiological Health
Rockville, Md. 20852

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THE AUTHORS

Dr. Wellman [1] is Chief, Biomedical Studies, Radiological Health Research Activities, Robert A. Taft Sanitary Engineering Center, U.S. Department of Health, Education, and Welfare, Public Health Service, Cincinnati; Mr. Karches is Assistant Chief, Radiological Health Research Activities, Robert A. Taft Sanitary Engineering Center; Dr. Hansen [2] is Chief, Radiological Research, St. Louis County Health Department; Mr. Laurer is Physicist, Institute of Industrial Medicine, New York University; Dr. Eisenbud is Professor, Institute of Industrial Medicine, New York University; and Mr. Fooks is Assistant Chief, Environmental Science Research, Research Branch, Division of Radiological Health, Public Health Service, Washington.

[1] Present address: Radioisotope Laboratory, Cincinnati General Hospital, University of Cincinnati.

[2] Present address: Department of Chemistry, St. Louis College of Pharmacy.

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ABSTRACT

Balance studies of environmental iodine 131 over a period of 30 days are reported in children ranging from 1 to 6 years of age. Calculations of expected thyroidal accumulations of iodine 131, based on accepted exponential models and thyroid function factors, are compared with thyroidal iodine 131 measurements performed in a low-background facility. The measured values were lower by a factor of 2 than the calculated accumulation of iodine 131, suggesting a lesser uptake and/or more rapid turnover of iodine in children. The difficulties involved in this type of environmental study and recommendations for improved methodology are discussed.

The Division of Radiological Health was reorganized January 1, 1967. It is now the National Center for Radiological Health with Mr. James G. Terrill, Jr., as the Director.

ACKNOWLEDGMENTS

The helpful guidance and invaluable suggestions of Dr. Conrad P. Straub throughout the investigation are gratefully appreciated. Without the diligent work of members of the St. Louis County Health Department, especially Miss Ruth Brennan, the study would not have been possible. Moreover, without the kind cooperation and patience of the children's parents, the study could not have taken place. Many other persons in the U.S. Department of Health, Education, and Welfare, Public Health Service, were also greatly responsible for accomplishing this investigation, especially Messrs. Byron Branson, Seymour Gold, and Lawrence Elfers, who provided excellent technical assistance. We also thank the medical staff of the University of Cincinnati Radioisotope Laboratories and Anesthesiology Departments, especially Drs. E. L. Saenger and A. E. Ogden, for their helpful advice; and Drs. Donald R. Chadwick, Arthur H. Wolff, Simon P. Abrahams, and Bernd Kahn of the U.S. Department of Health, Education, and Welfare, Public Health Service, for their help and encouragement.

INTRODUCTION

Resumption of atmospheric nuclear testing in September 1961 renewed concern about hazards to man from the fresh fission product radioiodine. Present hazard assessment methods are indirect, based on levels in environmental media and available formulae describing iodine metabolism. Not until recently have low-background facilities been used in an attempt to measure directly very low levels of environmental iodine 131 *in vivo* in the human thyroid (*1*).

A model of thyroid function was reported by the National Committee on Radiation Protection (NCRP) and the International Commission on Radiological Protection (ICRP), based upon clinical and experimental data (*2, 3*). Usually, the thyroidal iodine 131 uptake is assumed to be 30 percent and the turnover rate, or effective half-life, to be 7.6 days (*4*). Children can be considered the critical element in the population, since there is some evidence that the thyroid of the child is more susceptible than that of the adult to the hazards of radiation, and the ratio between the size of the thyroid and intake of radioiodine in children is different from the ratio in adults (*4*). Testing of nuclear devices produced radioiodine in sufficient quantity to elevate daily intakes in some localities above that amount thought to produce a thyroid dose of 1.5 rads per year in a 2-gram infant thyroid. The presence of atmospheric radioiodine, coupled with the availability of low-background shielded facilities for *in vivo* counting of radioiodine, made possible a study relating oral and possibly inhalational intake to thyroidal accumulation of environmental radioiodine. In addition, the practicability of employing these special facilities for assessment of thyroidal accumulation of ambient radioiodine could be evaluated.

Accordingly, a balance study in young children of iodine 131 oral intake and urinary output during a 30-day period of measurable environmental exposure was undertaken. From these balance data, thyroidal iodine 131 accumulation was calculated. Direct measurements of the children's thyroidal iodine 131 were made in a low-background shielded facility, and the data obtained were compared with the calculated values for thyroidal radioiodine.

METHODS

Study Group

Ten children, 1 to 6 years of age, from middle income families in the Metropolitan St. Louis, Mo., area, were studied in their homes for a period of 30 days, with the parents' cooperation. Because of limitations of the counting facilities, this group of 10 children, with their parents, was considered to be the maximum feasible size. Clinical examinations were performed on all children by their private pediatricians. Protein-bound iodines (PBI's) on all children were within normal limits. These data are given in table 1, along with other pertinent details concerning the study group.

Table 1. Balance Data, June 20–July 19, 1962

Subject	Sex	Age (yr-mo)	PBI (μg %)	Intake			Output	
				Milk (ml/day)[a]	Other fluids (ml/day)[a]	Cumulative 30-day I^{131} (pc)[a]	Urine (ml/day)	Cumulative 30-day I^{131} (pc)[a, b]
AM	F	4- 9	6.3	380± 80	510±270	240±20	910±190	130±17
BS	F	2- 3	7.1	250± 90	560±125	130±10	850±250	60±30
CG	F	3-10	6.6	200±100	290±150	150± 8	680±140	240±50
CN	M	2- 8	5.1	320±240	510±280	180±17	(c)	(c)
DG	F	5-10	6.9	410±160	410± 60	300±18	770±200	380±35
DH	M	1- 1	6.2	780± 30	180± 70	330±30	(c)	(c)
JH	F	2- 6	5.2	540± 90	370±140	490±19	810±250	300±70
JM	M	5-10	6.2	390±180	340±220	250±17	810±120	410±50
SM	M	2- 6	6.3	400± 90	300±180	250±18	810±190	60±60
TM	M	3-10	5.0	390±150	450±260	270±19	860±230	190±45
[d]$\overline{M}$			6.1	410±140	390±190	280±•40	810±220	220±•50

[a] Quantity $\pm 2\sigma$ counting error.
[b] At time of excretion.
[c] Diaper γ analyses for iodine 131 were not satisfactory.
[d] $\overline{M}$ = arithmetic mean.
• Combined 2σ deviation of population and counting error of analyses.

Balance Data Collection

During the investigation, all intake of food likely to contain fresh fission products (including fresh milk, milk products, produce, and water) was measured. All produce samples were washed as for cooking or consumption prior to radioassay. Particular emphasis was placed on precise measurement of milk intake, since it was considered the major source of radioiodine. Duplicates of all fresh foods actually consumed by the children were obtained for analysis. Special air-sampling techniques at one location in St. Louis were used to evaluate the concentration of iodine 131 in the air. To further assess the possible intake of radioiodine by inhalation during the study, vacuum-

sweeper collections were made in the individual homes as a reflection of the airborne radioiodine-bearing particulate concentrations.

Daily 24-hour urine collections were attempted for each child. Fecal samples were not obtained since iodine is excreted almost solely by the urinary route (*5*).

Methods of Analysis

All samples were analyzed by gamma spectroscopy for their gamma-emitting radionuclide content, principally iodine 131. Sodium iodide (Tl) 4- by 4-inch scintillation crystals (optically coupled to photomultiplier tubes in large 6-inch-thick steel shields, and connected to multichannel pulse height analyzers) were employed for the determinations. Constant geometries were obtained by means of calibrated Marinelli beakers (*6*). Smaller samples (<200 milliliters) were analyzed in plastic containers placed on top of the crystal in such a manner as to insure reproducible geometries. Simultaneous equation techniques were used to calculate the contributions of other gamma-emitting radionuclides in the samples affecting the 0.36-Mev. photopeak used to quantify iodine 131 (*7*). Samples of 3.5 liters with densities about equal to water were analyzed with a 6-percent efficiency, and 1-liter samples with a 10-percent efficiency. In both procedures, the minimum detectable level at the 95-percent confidence level was 10 picocuries per liter of sample with a counting time of 20 minutes.

Volumes of 3.5 liters were used for analyses of milk and tap water, which were measured in the gamma-spectroscopy equipment of the St. Louis County Health Department. All other samples were analyzed at the Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio. Urinary iodine 131 was determined in 1-liter Marinelli beakers, with the urine diluted with distilled water to 1 liter if the sample was not of sufficient size. All samples were corrected for physical decay to the time of ingestion or excretion.

Fresh milk products [1] and produce were analyzed for their iodine 131 content only qualitatively. Ten-liter beakers were used for the produce samples; however, geometries could not be made constant because the samples were not homogenized. Since qualitative gamma spectroscopy failed to detect the presence of iodine 131, quantitative analyses were not attempted on these samples.

Dust samples (vacuum-cleaner sweepings) were placed around the scintillation crystal in plastic bags to simulate an inverted-well geometry and were counted with an efficiency of about 5 percent. The glass

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[1] Those dairy products, exclusive of milk, that could reach the consumer in a sufficiently short period of time so that they might still contain radioiodine; for example, butter, ice cream, and cottage cheese.

fiber filters (8 by 12 inches) impregnated with sodium thiosulfate for retention of gaseous iodine 131, used to collect air particulates, were folded to 4 by 5 inches and placed directly on the crystal for counting.

Twenty-four-hour urine samples were collected daily during the study, and collection efficiencies were checked with daily creatinine outputs determined by the method of Jaffe (*8*, *9*, *10*). Iodine 131 determinations on urinary diapers from two of the children were attempted, but analyses could not be done satisfactorily; hence, output data were obtained in only eight of the children.

Urinary stable iodine, reflecting the iodine intake, was determined by a modification of the method of Chaney (cited in *11*). A microdistillation technique was used to isolate the iodine, after which it was quantified by determining the catalytic effect of odine on the ceric-arsenious reaction.

Thyroidal Iodine 131 Counts

The iodine 131 content of the children's thyroids was measured on two separate occasions during the study in the low-background facility at New York University's School of Industrial Medicine (*12*, *13*) to which the children were transported. Calibrations were performed using a rice-filled phantom (fig. 1). Glass simulated thyroids (fig. 2) representing 2, 4, 6, and 8 grams (that is, having 2-, 4-, 6-, and 8-milliliter volumes) were filled with the intercalibration iodine 131 standard at varying levels of activity. These were placed within the neck of the phantom at different depths and counted. Also, the crystals were placed in various counting geometries in relation to the simulated thyroids. The counting efficiency was found to be approximately 11 percent. It was found that thyroid size and depth of placement (within the range expected in the group of children under study) influenced the counting efficiency by ± 15 percent. Lateral movement of 1 to 2 centimeters by the crystals had no significant effect on the sensitivity. From previous calibrations for potassium 40 and cesium 137, their contributions to the 0.36-Mev. photopeak of iodine 131 were subtracted. With a 30-minute count, a minimum detectable level of 18 picocuries per thyroid gland at the 90 percent confidence level was achieved using the crystal configuration described below.

Because counting for periods of 30 minutes was required, the children were sedated with oral doses of 4 milligrams per kilogram of hydroxyzine as premedication and with small rectal doses (8 milligrams per kilogram) of thiopental sodium. Several reports have indicated that thiopental in large doses in animals may moderately depress thyroid uptake for short periods not exceeding one week (6). Since the children were counted immediately after minimal sedation,

Figure 1. Rice-Filled Phantom Used for Calibration

there would have been no effect on the existing concentration of iodine in the thyroid gland. Hydroxyzine has no observed effect on thyroid function (*14*).

The child was immobilized by the common medical practice of wrapping in a sheet and was placed in position for counting (fig. 3). The head was extended, allowing placement of 3- by 3-inch NaI (Tl) scintillation crystals next to the surface of the neck, over the thyroid (fig. 4). Thus, the optimum efficiency and geometry consistent with the circumstances were achieved.

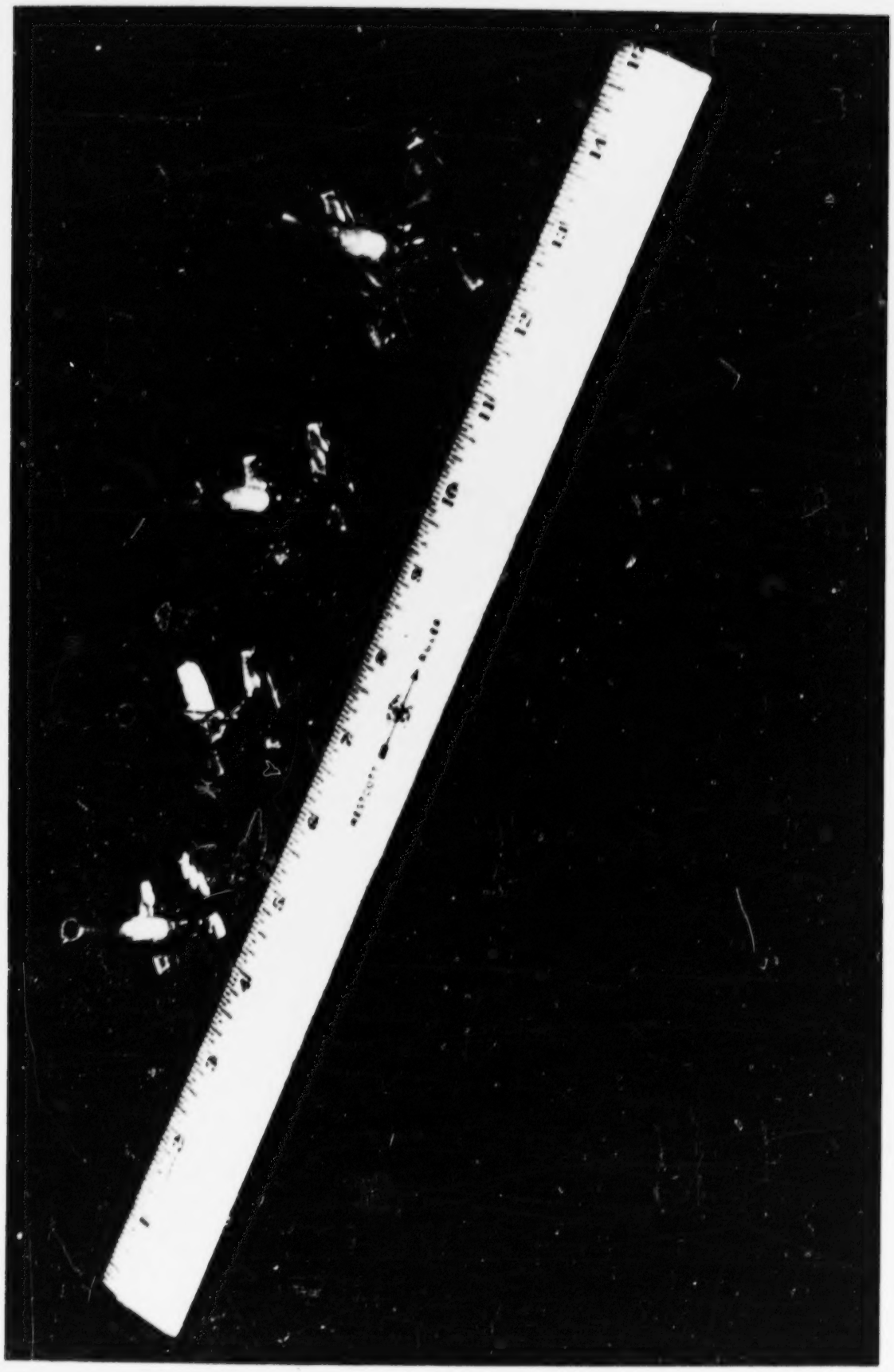

Figure 2. Simulated Thyroids

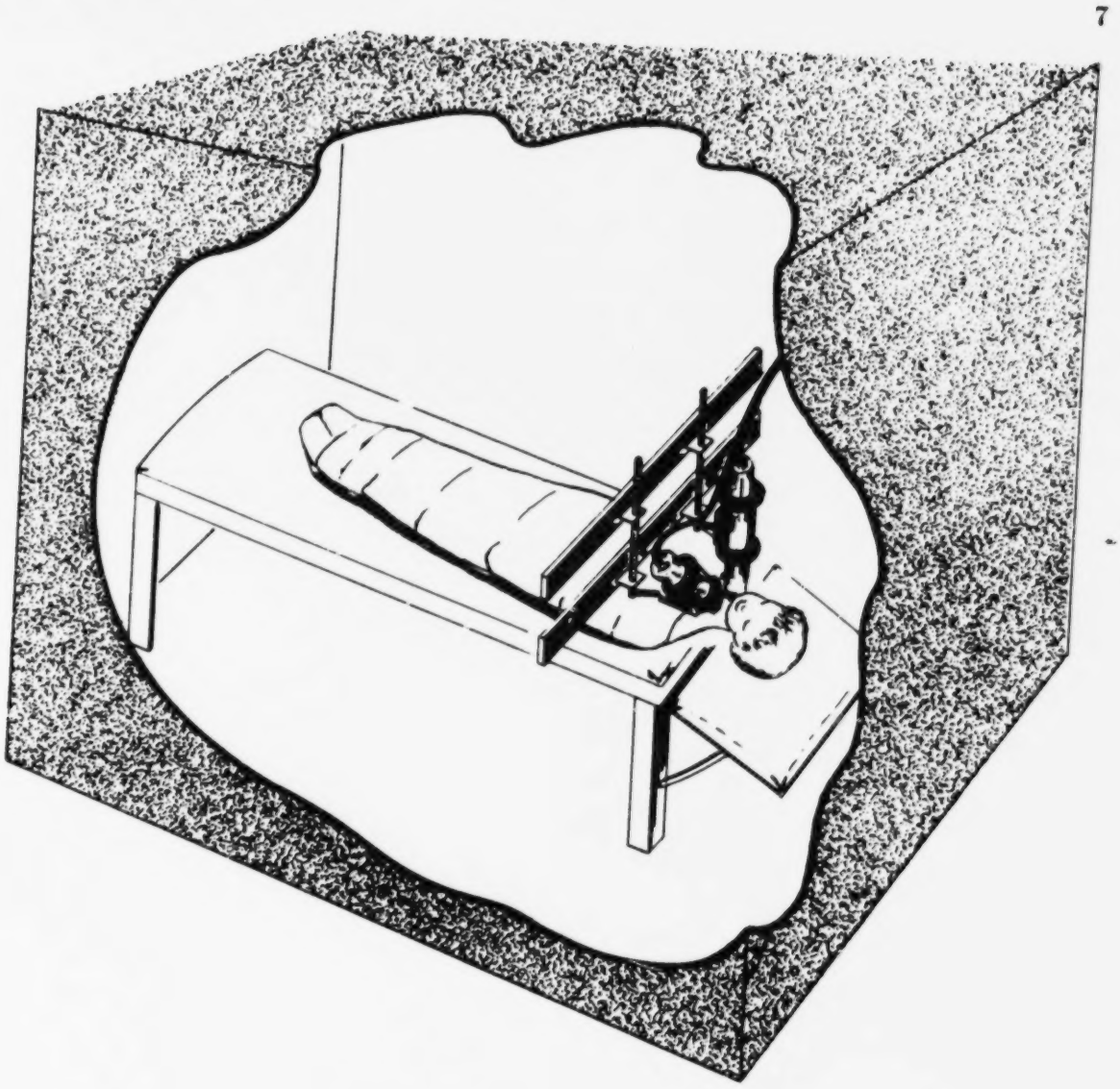

Figure 3. Immobilization

Intercalibrations

Because analyses were done at more than one institution, all equipment was intercalibrated with the same NBS standard of iodine 131 to insure valid comparison of analytical findings.

RESULTS

The study was begun on June 20, 1962, when iodine 131 milk levels were falling, after having reached a peak of 160 picocuries per liter 3 weeks earlier, as shown in table 2. During the study it was found that the iodine 131 concentration of the milk used by the children was usually somewhat lower than market milk [2] (pasteurized milk as com-

[2] The degree to which the iodine 131 concentration in consumed milk was lower than that in market milk would vary, depending on such factors as the length of time between purchases of milk by a family. Usually, the level in consumed milk was about 80 to 90 percent of the values reported in table 2.

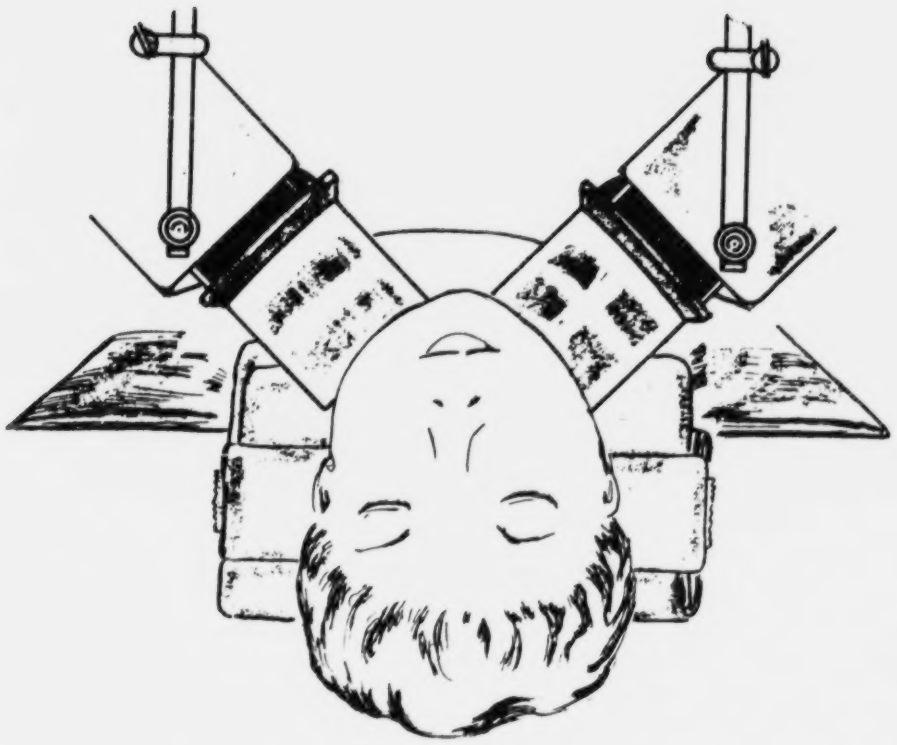

Figure 4. Crystal Placement

mercially available) because of the lapse of time between purchase and consumption. The mean intake of milk was 410±140 milliliters per day for the whole group with significant individual variations as shown in table 1. The total daily fluid intake very closely approximated the mean daily output of urine by the group, confirming an expected water balance.

The mean cumulative intake of iodine 131 for the group during this study was 280±40 picocuries. There were individual variations with the largest intake about four times the lowest. The cumulative urinary output of iodine 131 approached the oral intake value. It must be emphasized that the urinary iodine 131, with physical decay corrected to the time of excretion, will necessarily be less than the intake value because of physical decay in passage through the body. On the other hand, if relatively larger amounts of radioiodine were ingested just prior to the balance period, the urinary output would closely approximate or even exceed the intake.

Table 2. Iodine 131 in market milk, St. Louis area

Day of month	May 1962 (pc/l)	June 1962 (pc/l)	July 1962 (pc/l)
1	----------	160	40
2	----------	120	40
3	----------	120	30
4	----------	140	[a]ND
5	----------	110	ND
6	----------	90	10
7	----------	80	10
8	----------	70	10
9	----------	60	30
10	ND	60	20
11	ND	60	20
12	ND	30	20
13	ND	30	30
14	40	30	30
15	50	20	30
16	80	20	20
17	70	20	30
18	80	20	40
19	60	30	40
20	50	10	30
21	40	10	40
22	50	30	30
23	40	70	40
24	30	60	30
25	20	70	50
26	50	80	40
27	30	70	30
28	30	70	40
29	70	50	40
30	140	40	30
31	140	----------	20

[a] Not detectable.

Significant dietary iodine 131 levels were found only in the milk consumed. Of all the fresh produce, dairy products, and drinking water ingested, only one sample of fresh vegetables had a trace of iodine 131. No iodine 131 was detected in the special air filters. Most dust samples from the homes of the children contained measurable levels of iodine 131. During the second half of the study, detectable iodine 131 was present in dust samples from all the homes, as shown in table 3. These values were corrected for physical decay back to the middle of the respective collection period. Unfortunately, no reasonable conversion for iodine 131 could be made from dust to air concentrations to permit an accurate estimate of the inhalation of iodine 131.

Table 3. Dust particulate collections

(Activities in pc per iodine 131 sample)[a]

Family	June 20–28	July 1–19
G	80±70	60± 40
H	[b] ND	280±180
M	280±80	140± 90
N	ND	160±100
S	ND	1, 000±140

[a] 2σ counting error.
[b] Not detectable.

Table 4. Accumulated thyroidal iodine 131 at the time of thyroid counts

(Activities in pc/sample)

Subject	June 28		July 19	
	Calculated	Observed	Calculated	Observed
AM	57	32	22	2
BS	32	26	33	15
CG	23	14	19	36
CN	39	7	18	13
DG	50	20	36	21
DH	121	41	70	20
JH	87	31	46	29
JM	60	23	23	9
SM	59	17	23	13
TM	60	27	24	14
$\overline{M}$	59	24	31	17
Std error $2\sigma_{\overline{m}}$	±18	±6	±10	±5
t at 99% C.L.	5. 2		3. 9	
p	<0. 001		<0. 005	

The thyroidal content of iodine 131 was measured on two occasions. The observed levels of radioiodine are shown in table 4. The mean levels are higher on the first count than on the second, although on both occasions the values approached the limits of detectability. Only in the cases of CG and CN were the second measurements significantly greater than the first.

The daily milk iodine 131 intake data were used to calculate the expected thyroidal accumulation of iodine 131. The single exponential equation and factors commonly used to describe thyroid function were employed to make the calculations (*3*).

$$qf_2 = P(1-e^{-\lambda t})/\lambda \qquad (1)$$

where

qf_2 = burden of radionuclide in critical organ (pc),
f_2 = fraction of radionuclide in critical organ of that in total body,
λ = effective decay constant = 0.693/T,
T = effective half-life = 7.6 days for iodine 131,
t = period of exposure,
P = rate of uptake of the radionuclide by the critical body organ in pc/day, where the daily intake [concentration (pc/ml) x vol ml/day)] is constant and fraction reaching organ for iodine 131 is 0.3,
$\therefore$ P = 0.3 x pc/ml x ml/day = pc/day thyroidal uptake.

However, if,

$$P \neq \text{constant daily intake; i.e., } P_1, P_2, P_3, \ldots P_n$$

then

$$q_n f_2 = K \sum_{i=1}^{i=n} P_i e^{-(n-i)\lambda} \qquad (2)$$

where

i = integer days from 1 to n
K = 1 day
$(1-e^{-\lambda t})/\lambda = 0.98$ or ≈ 1, for iodine 131.

The mean daily milk intake of each child, shown in table 1, and the market milk concentration of iodine 131, shown in table 2, from May 14 (when iodine 131 again appeared in the milk in the study area) were used to calculate the daily iodine 131 intake for each child prior to beginning the study on June 20. It can be assumed that there would have been radioiodine in the children's thyroids as a result of this previous exposure. The calculated iodine 131 intake values were used in Eq. (2) to estimate the cumulative thyroidal iodine 131 during the

period prior to the study proper. Thus, the mean thyroidal iodine 131 level ($q_n f_2$) on the initial day of the study period could be approximated. During the balance study period, the intake of iodine 131 from the milk actually consumed was used in Eq. (2) to calculate day-to-day thyroidal accumulation.

The mean results for calculations of the daily thyroidal accumulation of iodine 131 are seen in figure 5. The dashed portion of the curve represents the prestudy period with market milk iodine 131 concentration and mean individual milk intakes. The solid section of the curve denotes daily thyroidal levels based on the measured iodine 131 oral intake data.

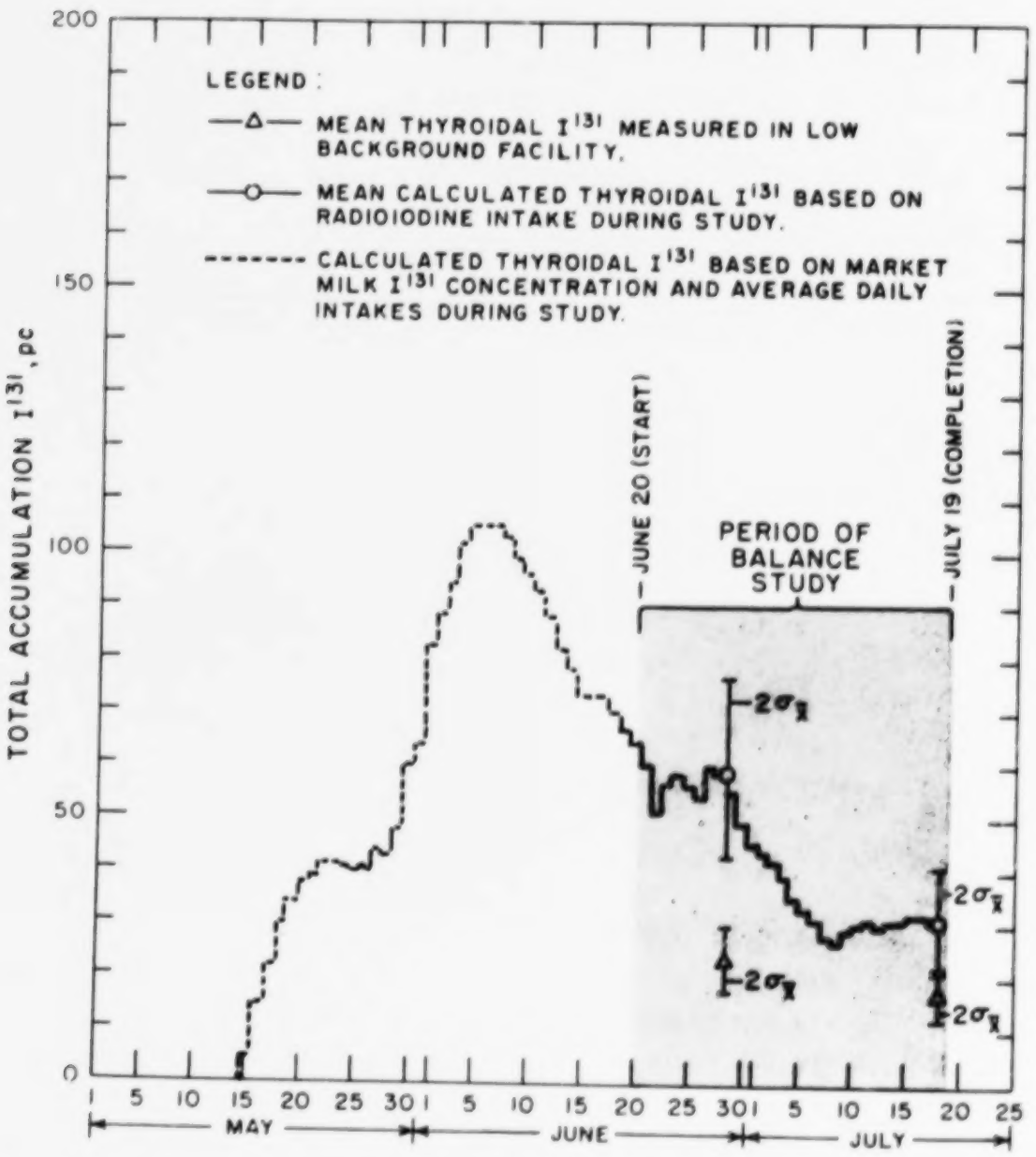

Figure 5. Mean Calculated and Measured Thyroidal Iodine 131 Accumulation in 10 Children

The mean values for measured thyroidal iodine 131 in the low-background facility on two separate occasions [1 week after beginning the study (June 28) and at the end of the study (July 19)] are denoted by the triangular symbols in figure 5. In the figure the standard error of the arithmetic mean at the 95-percent confidence level is given for the calculated and measured values. As can be seen, the actual measurements were lower than the calculated values by a factor of about 2. The pairs of values are significantly different at $p<0.001$ for the first measurement and $p<0.005$ for the second measurement at the 99-percent confidence level.

A high correlation was found between the first thyroid measurements and cumulative milk intake of iodine 131 from June 20 to June 28, with the correlation coefficient $r=+0.82$ (fig. 6). The iodine 131 intakes between the thyroid counts (June 28–July 19) do not correlate as well with the second counts, with $r=+0.39$ (fig. 6). The poorer correlation may be due in part to the second thyroid counts being near the lower limits of detectability. In comparison to the other children, subjects CG and CN had an unexplained higher level on the second count. The extremely low count of AM the second time represents a doubtful result.

The correlation coefficients are not meant to imply a given ratio for oral intake to thyroid level. Nor can the correlation interpret the degree of equilibrium. Rather these correlations indicate that no significant random errors influenced the data, with the possible exceptions of the values for CG and AM in the second period.

Urinary excretion of stable iodine, reflecting iodine intake, is shown in table 5. Not all urine samples were analyzed. These analyses were done only to assess the approximate daily stable iodine intakes. The mean daily urinary excretion of 190 micrograms of iodine is within the range of reported normal daily excretion (*5*). Since the iodine intake during the study was normal, there was no likelihood of suppression of thyroidal iodine uptake such as may occur with high dietary iodine intake. Saxena, Chapman, and Pryles (*15*) reported that the intake of iodine in children must be increased by about one milligram, or about five times normal, before significant depression of uptake occurs.

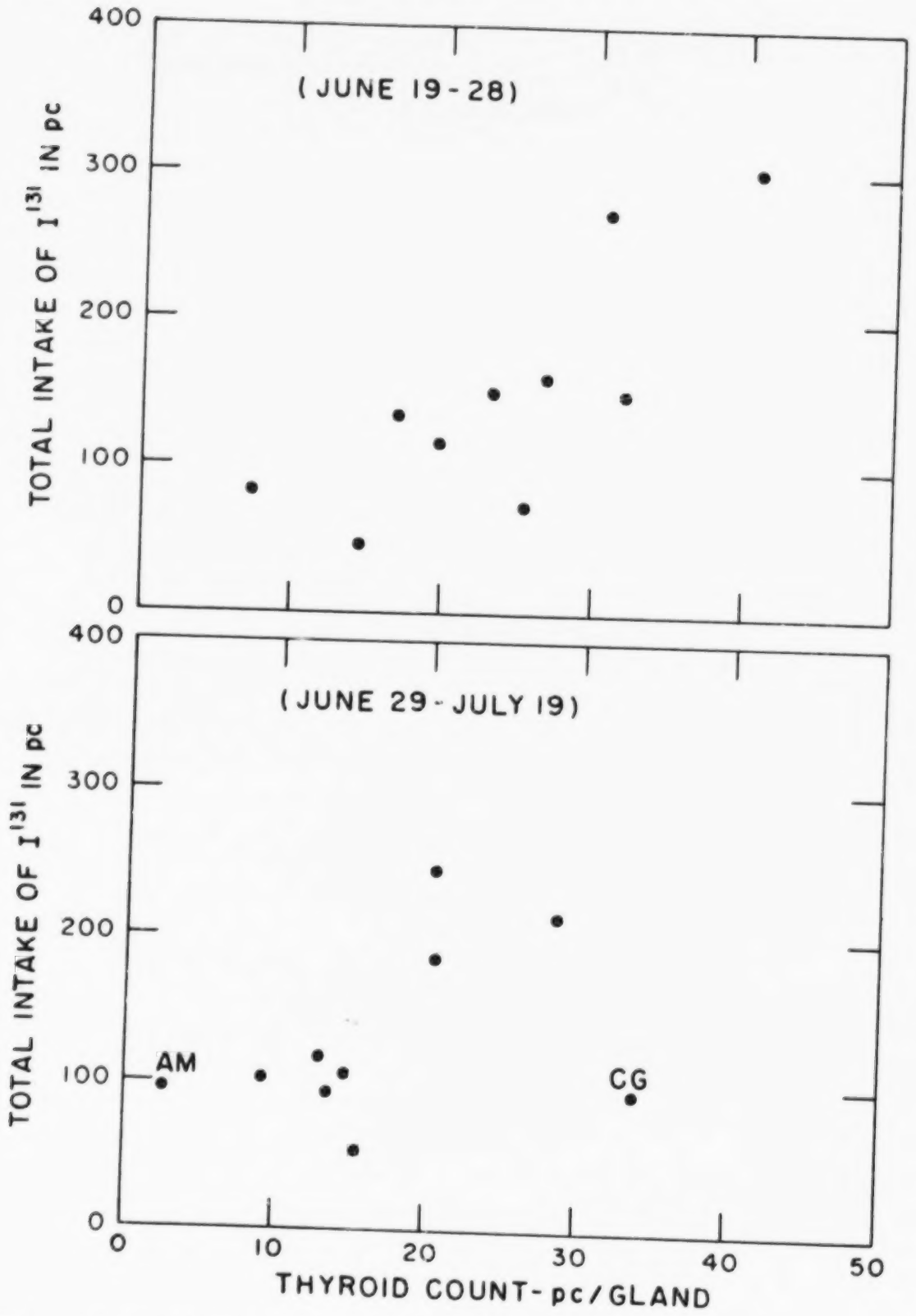

Figure 6. Intake of Iodine 131 Correlated With Thyroid Activity

Table 5. Urine stable iodine

	Mean concentration [a] (μg/100 ml)		Mean daily excretion (μg/24 hr)
AM	6	[b](2)	55
BS [c]	24	(15)	200
CG [c]	55	(13)	370
DG	26	(1)	200
JH	34	(3)	280
JM	15	(1)	120
SM	14	(2)	110
TM	18	(2)	160
Group means	24		190

[a] Analytical error $< \pm 2\%$ with concentrations >5 μg/100 ml.
[b] Number of determinations.
[c] Subjects BS and CG contribute more representative data since a greater number of samples of their urine were analyzed.

DISCUSSION

Although the mean daily milk level for the 37 days prior to the study was 64 picocuries, the thyroidal radioiodine levels approached the limits of detectability with the first measurement. With declining levels of iodine 131 in the milk, thyroidal iodine 131 levels were nearer the lower detectable limits at the time of the second thyroid count. This limiting factor made it difficult to achieve conclusive results. However, the results are considered suggestive enough to provide a basis for further investigation of the problem of environmental iodine 131 in man under more controlled conditions.

This type of study presents many difficulties. Working with pure environmental conditions introduces all the vagaries encountered in dealing with many uncontrolled, and often unknown, parameters. As far as possible, attempts were made to anticipate and properly recognize all variables. Standard conditions and routines (app. 1) were outlined so that explicit data could be collected for all known intake of radioiodine. Medical and nutritional histories (apps. 2–4) were obtained to provide practical clinical assurance of the normality of the children. There was, however, no absolute certainty that the complexity of environmental conditions was satisfactorily simplified for definite data interpretations.

The complexities were further compounded by many practical needs. Specialized equipment, available only in several different institutions, was necessary to accomplish precise analyses. These limitations required considerable handling of samples and subjects with frequent shipments and transport over long distances during the study. Furthermore, the cooperation of many people was necessary. Overall, the logistics involved were an additional potential source of variability.

Investigating of children of different ages requires a spectrum of calibrations. The procedures, however, are not yet completely satisfactory at very low radioiodine levels because of the variability of interfering factors, for example, thyroid size and position, and individual potassium 40 and cesium 137 contributions to the 0.36-Mev. iodine region of the gamma spectrum. The difficulty in maintaining an exact geometric configuration in small children is obvious, especially for the long counting period required at environmental levels. Sedation of the children was used to accomplish a fixed position, because a constant geometry was absolutely necessary. Sedation with barbiturates carries with it some slight risk of a reaction in the infant or young child (*16*).

The results, indicating a lesser thyroidal iodine 131 level than would have been anticipated (fig. 5), need to be checked by further investigation. This study suggests the possibility that the formulae and/or constants for thyroid function used to predict population exposure to environmental radioiodine (*4*), especially in children, may not be adequate.

Initially, either or both of the following explanations may be offered. First, the commonly used estimate of a 30-percent uptake (*4*) may be inappropriate for an environmental exposure. Also, this uptake estimate may not be applicable to children. Indeed, an uptake of 15 to 20 percent would have made calculated and measured values coincide. It must be recognized that this value has been achieved clinically and, while most useful, may be a relative and not an absolute thyroidal uptake. Second, the effective half-life of 7.6 days for iodine 131 may be too long, particularly in children.

Some previous work (*17*, *18*, *19*) and recent data (*20*) suggest mean iodine 131 uptakes in children more in the order of 20 percent. Unfortunately, only scant data on the effective half-life of iodine 131 in children are to be found. Oliner and others (*17*), and Fisher and others (*20*, *21*), report a more rapid rate of iodine 131 turnover in the child's thyroid, particularly below the age of 4.

CONCLUDING REMARKS

Future investigators should attempt more adequate control, eliminating as many variables as possible. In the diets of young children, it would usually be necessary to measure only the intake of iodine 131 in milk, since other media contribute little or no iodine. It would be better to use, throughout the experiment, milk containing iodine 131 decreasing proportionately to the physical decay. In this way, all iodine 131 ingested, excreted, and analyzed would be of the same age, making possible more accurate interpretation of its metabolism.

A relatively nontoxic ataractic, such as hydroxyzine (*14*), could be used in conjunction with immobilization by an apparatus used in clinical radiology, consisting of a malleable bag of plastic beads which becomes rigid when placed under a vacuum and immobilizes the part around which it is molded. It would be desirable to have counting times of not more than about 5 minutes.

The logistics of the experiment should be kept as simple as possible. For example, it would be helpful to have the investigation conducted in the same general geographical location as the performance of the analyses and thyroidal counts.

These recommendations would, it is hoped, provide more conclusive data in this particular area of public health. Emphatically, a good deal more data are necessary to accurately describe the relationship between environmental radioiodine levels and concomitant human thyroidal radiation exposure. Investigations of this kind would, of course, give more significant results if higher levels of intake of iodine 131 were involved.

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Appendix 1. Dietary intake record

Name: _____ _____ _____ Number ☐ ☐ ☐ ☐
Last First Middle

Ounces
A. ☐ ☐ Child's drinking glass.

Age: _____ _____
years months

Instructions for A.: Use measured glass.

B. Use this glass at every meal or between meals for milk.

C. Record in boxes for each meal the fraction of the glass of milk drunk (⅛, ¼, ½, ¾, 1).

D. Record amount in extra boxes of other milk products, fruits and vegetables, and water consumed. Estimate solids to nearest ⅛ cup.

Note: Any serious illness or diet change in space below.

_____

_____

Milk (Indicate date of sample) Date: _____

	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.	Sun
Breakfast							
Dinner							
Supper							
Other							
Other							
Other							

Milk products (Indicate date of sample) Date: _____

Breakfast							
Dinner							
Supper							
Other							
Other							
Other							

Fresh fruits and vegetables (Indicate date of sample) Date: _____

	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.	Sun.
Breakfast							
Dinner							
Supper							
Other							
Other							
Other							

Water Date: _____

Breakfast							
Dinner							
Supper							
Other							
Other							
Other							

Medications:

Date:

Does child routinely have iodized salt in food? yes_____ no_____

Appendix 2. Subject information

1. Date of interview mo. ☐☐ day ☐☐ yr. ☐☐

2. Patient number ☐☐☐☐

3. Name: _____ _____ _____
Last First Middle

4. Address: _____ _____
Street City (other—specify)

Phone: _____ Parents: _____

5. Birth date mo. ☐☐ day ☐☐ yr. ☐☐ Sex M. ☐ F. ☐ Age yr. ☐☐ mo. ☐☐

6. Weight lb. ☐☐☐ kg. ☐☐☐ Height cm. ☐☐☐ in. ☐☐☐

Percentile _____

7. Neck circumference (at base) in. ☐☐ cm. ☐☐ Thigh circumference in. ☐☐ cm. ☐☐

8. Siblings and ages (under 15 yr.) 1 ☐☐ 2 ☐☐ 3 ☐☐ 4 ☐☐ 5 ☐☐ 6 ☐☐

9. Length of residence in city yr. ☐☐ Previous residence _____

10. Has the child been in the city during the month before June 15, 1962?
yes _____ no _____

Appendix 3. Dietary history

1. Approximate amount of milk purchased per week for the family in quarts ☐ ☐ Exceptions in milk habits ___ _____

_____

2. Source of milk: Commercial dairy (specify) a. _____

b. _____

c. _____

Other (specify) _____

3. Type of milk used:

	All	Part
a. Pasteurized-homogenized	☐	☐
b. Homogenized	☐	☐
c. Skimmed	☐	☐
d. Powdered	☐	☐
e. Canned (evaporated)	☐	☐
f. Other (specify)	☐	☐

4. Best estimate of child's daily milk intake (in glasses) with meals ☐

between meals ☐

5. Other fresh milk products usually consumed weekly by family and children:

	Approx. freq. per week
a. Ice cream	☐
b. Malts	☐
c. Cottage cheese	☐
d. Other (specify)	☐

Appendix 4. Brief medical history

1. State of health — yes ☐ no ☐ Normal

Known illness (specify) _____

2, Growth and development — yes ☐ no ☐ Normal

Specify _____

3. Known thyroid disease and status (past and present)

Euthyroid ☐
Hypo- ☐
Hyper- ☐
Other ☐

Specify _____

4. Prior radiation — yes ☐ no ☐

a. Diagnosis (specify) _____

b. Treatment or test — yes ☐ no ☐

Specify _____

_____

Number of times ☐

5. Medications _____

_____

_____

_____

6. I^{131} therapy or test — yes ☐ no ☐

Where done _____

When _____

LABORATORY RESULTS

Ancillary test:

PBI _____

% I^{131} uptake _____

T eff _____

DIETARY HISTORY—continued

Average intake of food sources of iodine during past 3 months (fish, seafood, etc.).

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